AIRAH

Walk-in cool room and freezer research project

Barriers to energy efficiency

FINDINGS AND RECOMMENDATIONS

AN INDUSTRY GOVERNMENT INITIATIVE

SUPPORTED BY

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AIRAH

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About AIRAH

The Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) is an industry-led organisation that represents the entire heating, ventilation, air conditioning and refrigeration (HVAC&R) value chain, from the tradesperson on site through to university-educated engineers, researchers and business leaders. This overarching perspective – and reach to more than 25,000 industry participants – positions AIRAH well to develop and promote a safe, sustainable, healthy and comfortable built environment for Australia's future.

The 21st century imperatives of emissions reduction and energy productivity present our nation with significant change, challenges and opportunities. It is important that all stakeholders from the built environment and refrigeration sector come together to meet these challenges, because all of us have a part to play in achieving low emissions and in ensuring that technical challenges are met and risks are mitigated.

AIRAH collaborates with all levels of government to improve the environmental performance and safety considerations of existing and new HVAC&R systems. We envisage a collaborative effort to get and keep positive action firmly on the agenda. AIRAH appreciates that it is important for all stakeholders to understand not only the vital role the HVAC&R industry has in the wider economy, but also the role the industry can play in helping Australia achieve its environmental aspirations, and international and national commitments.

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Walk-in cool room research project

Barriers to energy efficiency

Findings and recommendations from an industry consultation into barriers to energy efficiency in the Walk-in cool room and freezer sector in Victoria.

Table of Contents

1 Executive summary

The primary objective of this project was to investigate the practices and system design, installation, operation and maintenance issues and barriers that lead to energy waste in the walk-in cool-room and walk-in freezer (WICF) sector.

AIRAH partnered with The Expert Group in an open engagement process with industry and key stakeholders to understand the key issues and barriers to energy efficiency. The research comprised initial desktop research to identify current standards, guidelines and regulations in Australia and internationally; 12 face-to-face interviews with key stakeholders; a whole of industry online survey (70 responses), email discussions (20 responses to share more in-depth information and documents), social media discussions and a face-to-face workshop with a diverse range of key stakeholders.

The research found the existing WICF supply chain is almost completely unregulated with very minimal to no guidance for contractors and end users regarding what constitutes minimum or good practice. Supplying, installing and maintaining WICFs is complicated and the industry participants are very disconnected, with issues affecting the supply of quality WICF products and services occurring on multiple levels and with significant opportunities for improvement.

There are many market failures and barriers hindering the uptake of higher efficiency equipment and contributing to energy waste, in particular information failure (i.e. supplier, contractor and end user), split incentives (i.e. where the owner of the equipment is not paying the energy bills) and least cost purchasing by small to medium enterprises (SMEs), in part driven by information failure. Contractors have little incentive to stay informed or promote new efficient technologies/solutions due to the increased complexity and capital cost of high efficiency equipment and when they are selling to end users primarily interested in least cost equipment.

In summary there is:

- No good practice guideline or technical standard for WICFs that covers design, installation, commissioning and maintenance;
- No requirement to undertake a Heat load calculation for a WICF (i.e. required for air conditioning);
- No or minimal documentation provided to the contractor or end user (i.e. installation, commissioning, operation, maintenance);
- No requirement for specific skills except a refrigerant handling licence (RHL) when installing equipment that requires charging with refrigerant;
- Unlike the large majority of all other building structures in the economy, the National Construction Code (NCC) has no energy efficiency requirements for WICFs. The NCC has some safety requirements such as emergency exit, bell on door, etc. on new WICFs;
- No efficiency measure or label requirement under Greenhouse and Energy Minimum Standards (GEMS) Act for the end user to understand what the WICF may cost to operate or what constitutes poor or good efficiency (i.e. no star rating); and,
- Information failure, split incentive and least cost purchasing are the primary reasons for energy waste in the WICFs sector.

2 Key Recommendations

The key recommendations following the industry consultation and research are:

- A Code of Practice that encompasses design, installation, commissioning and maintenance is strongly recommended;
- Industry training based on the Code of Practice is strongly recommended;
- A deemed to comply star rating system and label should be considered:
  - Communicates to key stakeholders (i.e. contractors and end users) what constitutes poor and high efficiency WICF;
  - Provides framework for incentives via deeming method in the Victorian Energy Upgrades program; and,
  - Both information and incentives will assist with key market failures and barriers to energy efficiency in this sector (i.e. no guidance or information and least cost purchasing by SMEs).
- The documentation, operation and maintenance requirements due to come into force via AS/NZS 5149 part 4:2016 can be reinforced in the Code of Practice (refer Section 7.3 for overview of requirements);
- The maintenance requirements in the Code of Practice should be encompassed in AIRAH DA19 HVAC&R Maintenance;
- A star rating label and rating plate for WICFs under the GEMS Regulations should be considered as a mandatory or voluntary measure to assist with barriers to energy efficiency;
- Sustainability Victoria to consider communication for end users such as operator guide and maintenance guide for efficient WICFs. The guide can reference AS/NZS 5149:2016 part 4: 2016 to remind end users of their operation and maintenance obligations;
- Undertake behavioural insights research / ethnographic study to better understand installers and users behaviours and what drives them;
- Other tools that should be considered are:
  - Payback calculator and industry agreed assumptions for communicating energy savings; Or industry agreed assumptions in the Code of Practice and provide scope for supplier calculators;
  - Once a Code of Practice is established this provides scope for use in other standards and regulations (i.e. National Construction Code, The Ozone Protection and Synthetic Greenhouse Gas Management Act 1989, related Acts and requirements of the Refrigerant Handling Licence); and,
  - Industry standard Heat load calculator.

3 Project Objective

The primary objective of this project was to provide visibility to AIRAH, Victorian Department of the Environment, Water, Land and Planning (DEWLP) and the HVAC&R industry of the practices and system design, installation, operation and maintenance issues that lead to energy waste in the walk-in cool room and freezer (WICF) sector.

This report identifies the main barriers to energy efficiency and suggested recommendations from a range of key stakeholders for improving energy efficiency. The report identifies priorities and suggested next steps for AIRAH and the industry to implement these solutions and provide information to help inform government policy development.

4 Industry Engagement Process

AIRAH partnered with The Expert Group and undertook an open process to engage with industry and key stakeholders to understand barriers to energy efficiency. Initial research was also undertaken to identify current standards and guidelines for WICFs.

This industry research was conducted between May and July 2018. The research included 12 face-to-face interviews with key stakeholders, a whole of industry online survey (70 responses), social media discussions and a face-to-face workshop. A discussion paper was developed and made publicly available for comment. This was based on the face-to-face interviews and industry survey and was used to inform the face to face workshop.

The Discussion Paper is available for download at:
http://www.airah.org.au/Content_Files/Advocacy/2018/190718-AIRAH-WIC-Discussion-paper.pdf

The key stakeholder groups included in the process include:

- Equipment manufacturers and suppliers;
- Installation and maintenance contractors;
- Cleaning contractors;
- Designers, refrigeration engineers and environmental consultants;
- Training practitioners;
- End users (i.e. supermarkets);
- Energy retailers;
- Government employees responsible for energy efficiency policy and resource efficiency programs;
- Controls companies;
- Cold room panel manufacturers;
- Policy; and
- Social scientists.

Face-to-face workshop hosted in Melbourne

5 Background and size of the problem

There are around 260,000 walk-in cool rooms and freezers in Australia with approximately 26% of those in Victoria[1] Approximately 80% are cool rooms and 20% are freezers.

There are 260,000 walk in cool rooms and freezers in Australia

Potential energy use in cool rooms and freezers in Australia is 4,800 GWh per annum with around 1,250 GWh consumed in Victoria. The average unit energy consumption is around 18,800 kWh per annum and the potential energy waste is conservatively more than 25%.

Potential energy use in cool rooms and freezers … is around 1,250 GWh in Victoria

[1] *Population pro-rata is sound proxy for refrigeration equipment as the main applications relate to consumption of foodstuffs and beverages by people.*

…potential energy wastage is conservatively more than 25%.

The national energy spend is $775 million based on AEMO 2016 average commercial electricity price of 16c/kWh and is much higher in 2018 due to recent electricity price increases.

Walk-in cool rooms and freezers are predominantly installed, owned and operated by small to medium enterprises (SMEs) across the refrigerated cold food chain from farm gate to supermarket (including all the independent supermarkets), and hospitality, convenience stores, restaurants and institutions (i.e. hospitals, universities). There has been significant growth in this sector over the last seven years, with condensing unit and evaporator sales growing at more than 3.5% compound growth per annum.

There are essentially three main factors that affect indirect emissions from walk-in cool rooms and freezers:

System efficiency – influenced by design, installation, operation and maintenance.

System load and energy consumption – influenced by the cool room design (R-value of walls, floors and walls, and, solar gain), system design, efficiency characteristics of installed equipment and components, any local micro-climate effects (i.e. ambient temperature), air and moisture sealing, process efficiency, temperature settings, the modes and methods of operation and control, end user behaviour (i.e. air infiltration) and maintenance. Understanding and reducing system load is critical as it can reduce energy consumption without improved efficiency.

Carbon intensity of energy source – influenced by fuel source for electricity generation (solar, coal, gas, etc) and by fuel type used on site (electricity, gas).

Direct emissions from cool rooms and freezers are also relevant as they typically have the highest leak rates (~15% per annum) in the economy and use high global warming potential (GWP) refrigerants (i.e. HFC-404A GWP of 3922, HFC-134a GWP of 1430 and HCFC-22 GWP of 1810).

Direct emissions from cool rooms and freezers are … typically highest leak rates in the RAC industry (~15% per annum)

This study primarily focuses on the first two items. Common industry practices, equipment types and operational issues have not changed much over the last decade or since the last formal review into this sector *In From the Cold* by Equipment Energy Efficiency (E3) program published in 2009[2]. The main differences since the last review is there are more energy saving opportunities available due to the growth in the market and to advancements in technology, however they are often not taken up due to information failures, split incentives and the least cost capital purchase approach of many customers.

[2] *Refer Section 6: Walk-in cool rooms, http://energyrating.gov.au/document/report-cold-background-technical-report-volume-2.*

6 Definition of walk-in cool room and walk-in freezer

Walk-in coolroom and walk-in freezer (WICF) means an enclosed storage space refrigerated to temperatures, respectively, above, and at, or below 0°C that can be walked into. It also includes those WICFs with display panels and doors and non-display panels and doors.

This includes walk-in cool rooms (WICs) used for retail applications and liquor outlets where the consumer can reach into the WIC via a glass door (i.e. convenience stores) or walk into the WIC (i.e. liquor outlet) to select beverages and foodstuffs. These types of WICs typically have transparent doors (i.e. glass) and windows.

Components that affect energy consumption include refrigeration equipment (condensing unit[3] and evaporator, or packaged drop-in/slide-in units), controls (integrated or separate), defrost method or control type (electric, hot gas, off-cycle air, water, ambient air or demand), doors, sealing, lights, windows, walls and floors.

Exclusions:

The following are not included in our definition of WICF:

- Refrigeration display cases and merchandisers;
- Refrigerated storage or service cabinets typically used in commercial kitchens;
- Cold storage facilities with a chilled storage area ≥ 280 m^2; and,
- Equipment and products exclusively for medical, scientific, or research purposes.

Other applications that may or may not be included are:

- Food preparation rooms where the temperatures may be 12 to 18°C where they may have lower air flows to prevent draughts, require lower noise levels for operators and be humidity controlled.
- Process applications that include cool rooms with the introduction of other gases (e.g. ripening rooms with non-standard atmospheres).

Table 1: WICF nominal sizes.[4]

Description	Dimensions	Nominal capacity (Wr at 5°C)
Mini	< 9 m^2 x 3 m high	2,250
Small	≥ 9 m^2 and < 24 m^2 x 3 m high	4,100
Medium	≥ 24 m^2 and < 36 m^2 x 4 m high	9,000
Large	≥ 36 m^2 and < 280 m^2 x 4 m high	20,400

[3] *Condensing unit means a product integrating at least one electrically driven compressor and one condenser, capable of cooling down and continuously maintaining low or medium temperature inside a refrigerated appliance or system, using a vapour compression cycle once connected to an evaporator and an expansion device.*
[4] *Small warehouse is greater than 100 m^2 and up to 7m high.*

Figure 1: New walk in cool room with three evaporators.

Figure 2: Conventional condensing unit that is typically located outdoors to reject heat.

7 International standards and guidelines

7.1 USA

The US Department of Energy (US DoE) introduced efficiency requirements and test methods for Walk-in Cool rooms and Freezers (WICFs) taking effect from 1 January 2009.

These set out the initial minimum design requirements for WICFs operating both above and below 0°C with chilled storage area of less than 278.71 m^2, covering construction materials and electrical energy using components. It includes those with display panels and doors and non-display panels and doors. Based on minimum insulation requirement (R-values) for insulated panels and doors and in addition design/construction requirements for components that has an effect on the Heat load. Effective from June 2017 WICFs have minimum Annual Walk-in Energy Factor (AWEF) specified based on net capacity and labelling requirements.

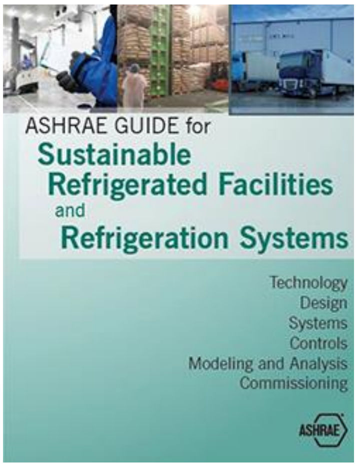
ASHRAE Guide for Sustainable Refrigerated Facilities and Refrigeration Systems, June 2018 provides comprehensive coverage of refrigeration systems and structures to ensure the sustainability of refrigerated facilities.

The guidebook covers the fundamentals for those new to refrigeration and refrigerated facilities while also including advanced concepts in design and controls for experienced professionals involved with planning, designing and operating refrigerated facilities. Whilst this guidebook is mostly aimed at facilities larger than 278.71 m^2 it includes an introduction to sustainable refrigeration and reviews of:

- The basics of refrigeration technology;
- Refrigerated facility design and Heat load calculation;
- Design of the refrigeration system;
- Control and control strategies;
- Energy modelling and performance analysis; and,
- Commissioning.

The guideline includes access to practical online tools for estimating Heat load, coefficient of performance (COP), and engine room energy use, as well as a refrigeration design scorecard.

The guideline includes two New Zealand authors, Don Cleland and Richard Love.



7.2 Europe

European Union (EU) Standards covering the performance of Walk-in Cold Rooms are currently being developed in Europe to meet the requirements of the Energy Related Products (ErP) regulations including:

- *EN 16855-1:2017 Walk-in cold rooms – Definition, thermal insulation performance and test methods – Part 1: Prefabricated cold room kits.*
- *Draft EN 16855.2:2017 Walk-in cold rooms – Definition, thermal insulation performance and test methods – Part 2: Customised cold room kits.*

These standards reference ISO and EN standards relating to thermal performance of structures, windows, doors and shutters, as well as *EN 13771-2:2017 Compressors and condensing units for refrigeration - performance testing and test methods.*

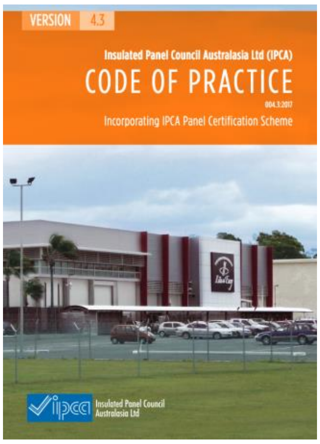
The UK Institute of Refrigeration (IOR) has a range of Guides to Good Commercial Refrigeration Practice and Guidance Notes that were published around 2009/10, many of which focus on design, installation, refrigerant containment and maintenance. The IOR more recently published Codes of Practice on the following:

- *Cold Store Code of Practice (published 2015, amended 2016);*
- *Safety Code of Practice for Ammonia Refrigerant R717 (Group B2L); and,*
- *Carbon Dioxide (R744/CO2) Refrigerant Code of Practice.*

7.3 Australia and New Zealand

There are several guides and technical standards relevant to WICFs in Australian and New Zealand, however none of them encompasses design, installation, commissioning and maintenance from an energy efficiency perspective. The relevant guides and technical standards are as follows:

IPCA Code of Practice V4.2 published by Insulated Panel Council of Australia (IPCA) that covers structures built using Insulated Sandwich Panels (ISPs) and Expanded Polystyrene Fire Resistant (EPS-FR) insulated panels relating primarily to fire safety. As discussed at the workshop, the IPCA Code of Practice is adopted by around 40% of the industry and provides no guidance on energy efficiency. The code is mostly about construction and fire risk mitigation which relates to insurance, and the structure is registered and labelled.



Safe operation of cold storage facilities published by WorkSafe Victoria, June 2017, that covers a number of operational aspect as well as some design aspects relating to safety.

Coldstore Engineering in New Zealand – IPENZ Practice Note 15, covers all aspects of coldstores, including insulation, refrigeration, electrical, structure, operations and maintenance.

AS/NZS 5149 part 4:2016 Refrigerating systems and heat pumps - Safety and environmental requirements Operation, maintenance, repair and recovery, is due to come into force soon via various State and Federal regulatory instruments.[5] *AS/NZS 5149 part 4:2016* includes operation instruction obligations for equipment owner, operator and contractor such as:

- Care shall be taken to ensure that the personnel charged with the operation, supervision and maintenance of the refrigerating system are adequately instructed and competent with respect to their tasks;
- Before a new refrigerating system is put into service, the person responsible for placing the system in operation shall ensure that the operating personnel are instructed on the basis of the instruction manual about the construction, supervision, operation and maintenance of the refrigerating system, as well as the safety measures to be observed, and the properties and handling of the refrigerant used;
- Each refrigerating system shall be subjected to preventive maintenance in accordance with the instruction manual. The frequency of such maintenance depends on the type, size, age, use, etc. of the system. In many cases more than one maintenance service is required in the course of one year in accordance with legal requirements; and,
- The party concerned shall keep an updated logbook of the refrigerating system. The logbook shall record details of all maintenance and repair work; quantities and kind refrigerants used; changes and replacements of components of the system; and results of all periodic routine tests.

[5] *At present AS/NZS 5149-4: 2016 may be called up as a contractual requirement. There are plans to for this standard to be referenced in the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and related Acts (the OSGG Acts) late 2018.*

8 Technology and practices

8.1 Refrigeration technology

Refrigeration technology used in this sector has remained relatively stagnant or conventional for much of the last twenty years, and new technology opportunities that can achieve savings of more than 25% have only recently emerged.

The existing stock of equipment comprises three configuration types:

- Drop-in/slide-in packaged sealed units for small WICFs typically up to 24 m^2 accounting for less than 5% of WICFs based on stock;
- Remote condensing unit located outside (or on top of the WICF) with one evaporator (one to one) or multiple evaporators on larger cool rooms; and,
- Small systems where there may be multiple refrigeration requirements for a cool room, freezer and display cases for a retail outlet (i.e. convenience store).

A remote condenser and evaporator installed in "one-on-one" arrangements account for the very large majority of applications. They typically use conventional hermetic reciprocating compressor technology, without electric commutated (EC) fans, basic controls and electric defrost on a timer. This sector is mostly served by basic refrigeration contractors working to the lowest denominator to cater for the needs of SMEs with least capital cost behaviour and wanting minimum maintenance costs. These contractors generally do not consider electricity consumption and running costs. These contractors would typically have a certificate III in refrigeration and air conditioning and hold an Australian Refrigeration Council (ARC) refrigerant handling licence.

The new and emerging technology options include:

- DC technology (DC compressors, EC fans and electronic controls) that mimic air conditioning split systems technology to achieve flat line temperature control and can save more than 25% of energy consumption;
- Pulse modulation semi-hermetic compressors with inverters, EC fans and room temperature probes to provide improved refrigerant and capacity control suited to larger one on one applications;
- Self-contained small capacity direct expansion (DX) CO_2 cascade low temperature system, designed to be close coupled to the evaporator and connected to a high side medium temperature ring main to satisfy multiple applications;
- CO_2 trans-critical systems with a mix of technology enhancement add-ons including booster systems, parallel compression groups, ejectors, adiabatic coolers, evaporative pre-cooling, indirect evaporative/dew point coolers and mechanical sub-cooling;
- Low charge HC based systems with charges within AS/NZS 5149:2016 charge limits, suitable for condensation against water loops; and,
- The Internet of Things (IoT) is emerging in medium sized refrigeration technology to make products more intelligent and user friendly.

Other opportunities include larger evaporators, larger condensers, higher efficiency/variable speed compressors and fans. For example, some hermetic compressors' isentropic efficiency can be less than 50% whereas more efficient compressors can have isentropic efficiencies greater than 60%. An improvement from 40% to 60% efficiency can result in a 25% to 35% reduction in energy if all other factors remain the same. Variable speed compressors offer the potential of better temperature control as well as potentially improved efficiency (i.e. higher evaporation and lower condensing temperatures at part speed most of the time rather than full speed a fraction of the time).

Ammonia equipment is best suited to larger applications beyond the scope of this work and hydrocarbon is a potential candidate for small WICFs providing the requirements of *AS/NZS 5149.1:2016 Refrigerating systems and heat pumps - Safety and environmental requirements* can be met.

8.2 Controls including defrost controls

WICF control types can vary from basic on-off control thermostats and an electric defrost timer to sophisticated electronic cold room controllers with smart or demand defrost.

Common practice is to use a basic electric defrost timer (i.e. switches on 4 to 6 times per day). Contractors use this because it's the easiest solution, but it is the most expensive to run. An alternative control approach is electric on demand via a controller based on temperature termination (i.e. switches off based on set point). Hot gas defrost is less common as it can be problematic[6] and less common options include reticulating phase change materials.

Specialist cold room controllers that optimise the benefits of DC inverter technology have recently emerged to mimic the split system concept. These dedicated WICF controllers adopt an integrated approach that connects the controller, condensing unit, evaporator and electronic thermal expansion valve (TX) to achieve flat line temperature control (as close as practically possible). Other features include demand defrost and accessories to offer IoT features such as data logging and maintenance reminders and logs.

8.3 Cool room and freezer structure

The recommendations from *In From the Cold*[7], published almost a decade ago for minimum standards on all structural aspects that affect the thermal performance of the WICFs and major equipment is still considered a sound technical position. The recommendations relating to the structure were to harmonise with the regulations introduced by the US Department of Energy, 1 January 2009, as follows:

- Insulation panels for walls, ceilings and doors are to have an R-value of at least 4.5 m^2K/W which equates to 100 mm polyisocyanurate (PIR) or thicker than 140 mm expanded polystyrene (EPS) on cool rooms and 6.0 m^2K/W (thicker than 150 mm PIR) on freezers;[8]
- Minimum thermal insulation ratings on floors of at least 4.9 m^2K/W for all WICFs;[9]
- Transparent windows and doors to have double glazed on cool rooms and triple glazed on freezers; all glass panes to have heat reflective treatment and gas fill;
- Proper sealing of room, which prescribes the joins of insulation panels, types of doors and door gaskets; and,
- Energy-efficient interior lighting to have an efficiency equal to or better than LED lights.

6 *Except in the case of some drop-in/slide-in packaged systems where the hot gas defrost is factory pre-set.*
7 *Refer page 115, http://energyrating.gov.au/document/report-cold-background-technical-report-volume-2.*
8 *K_{PIR} = 0.025 W/m°K and K_{PIR} = 0.035 W/m°K, therefore 100 mm PIR will be around 140% thicker with EPS to achieve 4.5 m^2K/W.*
9 *Some structures need to consider frost heave; however, this is more so considered a structural consideration.*

The general view from the insulation panel industry participants at the workshop is they can supply either PIR or EPS in a range of thicknesses and thermal ratings, however currently supply the market and customers with what they specify.

Other considerations raised regarding the structure are:

- The cladding type is important as it can range from aluminium (i.e. different gauges), plastic, stainless steel and checker plate up to a height to prevent damage (i.e. trolleys, fork trucks, etc.);
- Bollards/rails to protect panel along accessible walls;
- Damaged panels absorb moisture and are less thermally efficient;
- Undertaking performance checks on medium and large WICFs every 5 years is good practice. For example, if the heat-loss was 100 $W/m^2/^oC$ when installed and when retested it was twice that you know you have problems. This is particularly relevant with WICFs located outside (i.e. not in a conditioned space);
- The thermal rating to suit local ambient conditions and room internal temperature and must be fire rated;
- Essential that freezers have floor insulation and in many instances floor heating for frost heave protection;
- A full vapour seal is important with all penetrations correctly sealed;
- Must have strip doors, spring hinged doors, or other method of minimizing infiltration when doors are open; and,
- Automatic door closers on doors for WICFs with fork truck access.

8.4 Good practice design, installation, commissioning and maintenance

Good design involves undertaking Heat load calculations for the application and correctly matching equipment (i.e. condensing units and evaporators) to meet the design load.

There is no Australian industry design guide or standard, however all major suppliers of commercial refrigeration equipment (including Actrol, Airefig, Beijer, Bitzer and Heatcraft) have proprietary Heat load calculators and product selectors to ensure the equipment is selected for the application.

A Heat load calculation takes into account the product entering time period and frequency; set point temperature; condenser ambient conditions (38^{o}C or 43^{o}C); product characteristics such as specific heat, latent heat for freezers, heat of respiration for many fruits and vegetables, and packaging; WICF dimensions and R-values for walls, floors and windows; door opening frequency; defrost type; and, typically a 10% safety factor to calculate the refrigeration load required based on a run time of 16 hours per day or other design considerations.

Understanding and reducing system load is critical as it can reduce energy consumption without improved efficiency. For example, air infiltration is the major and most variable Heat load and provides the greatest opportunity for improvement. However, contractors installing the equipment rarely undertake Heat load calculations, they are mostly undertaken by the wholesalers. There is often a disconnect between the intended design and the end user as information required for Heat load calculation and design needs to flow up the supply line from end user to builder to contractor to supplier/wholesaler which creates numerous opportunities for information to be lost or misinterpreted. Other areas for potential improvement to reduce loads are higher efficiency fans and fan motors; similarly, lights can introduce un-necessary loads (e.g. LEDs with motion sensors reduce loads); and defrost type (i.e. electric defrost increases the load) and how it is controlled can waste energy.

The disconnect between the end-user/owner and the designer means that the designer is "in the dark" and has to make assumptions around likely usage (i.e. product and air infiltration loads) that can lead to un-necessary safety margins and defaulting to lowest first cost pricing options.

Good practice installation involves practical considerations such as evaporator and condensing unit positioning. For example, the evaporator should be located so cold air does not blow straight out the door[10] and condensers must be located where there is good air flow and waste heat can be discharged. It is also important to minimise air infiltration through appropriate cool room construction and door design and placement. Air infiltration not only creates additional refrigeration load, it lets moisture into the WICF which ices up the evaporator (i.e. require more defrost) and can result in ice forming on the floor.

Common feedback from participants surveyed and interviewed concerned the extent of poor commissioning, particularly not setting up superheats correctly during initial installation, which typically results in poor performance for the lifespan of the equipment. Setting up superheats correctly improves evaporator performance (i.e. higher evaporation temperature, greater capacity and higher energy efficiency) and can enable operation with lower head pressures (e.g. floating) which improves energy efficiency.

Dirty coils, blocked drains, defrost not working and high refrigerant leak rates (~15% per annum) are other issues that feedback indicates are common place in this sector. Scheduled preventative maintenance should comprise checking for refrigerant leaks, loose electrical connections, superheat, indoor and outdoor coils are clean and defrosts are adequate (not overheating the cold room).

In practice preventative maintenance is simply not recognised as a task that contributes to the bottom line. Rather breakdown repair, or "fail and fix" where end users simply wait for equipment to fail before fixing it is more common place. Poor hygiene (build-up of plastic bags, hair, lint, dirt and bugs on coils) and poor maintenance was a consistent theme throughout the survey feedback. Most participants suggested quarterly maintenance checks, and monthly with larger systems (i.e. refrigerant charge >20 kg and over 20 kWr) is what is required to maintain good equipment performance.

There is no statutory requirement to undertake a Heat load calculation or maintain records so currently contractors undertaking maintenance of an existing system lack an understanding of the basis of the design or when it was last serviced.

8.5 Education, installation and operation instructions and documentation

Unlike air conditioning, refrigeration equipment typically does not come with installation or operation guidelines. They are considered a custom design, and documentation is the responsibility of the installer. The extent of the documentation may typically include equipment data sheets and the controller operator manual.

There are no minimum performance requirements for WICFs or associated refrigeration equipment, and no requirement to fix a performance label. Whereas the large majority of air conditioning types must

[10] *It was noted at the workshop there are opposing views held by contractors on this topic where positioning depends on the circumstances.*

satisfy minimum performance requirements under the Greenhouse and Energy Minimum Standards (GEMS) Act.

There are many common sense operational factors that are commonly ignored that result in poor performance and increased energy consumption. Potential areas for improvement include:

- A loading and unloading policy: When product arrives, you need to ensure that it doesn't warm up any more than necessary, so load it as quickly as possible into your freezer.
- A lot of cool air is lost during opening and closing doors.
- Don't overload the WICF or stack produce in front of evaporator.
- Don't load equipment on top or in front of condensing units.
- Turn the lights off when not required.
- Door alarms are cheap but are no good if they are ignored or disabled.
- There is no specific training available for designing, installing or operating WICFs.

8.6 Potential educational opportunities include:

- Guideline on the energy saving benefits of key energy saving initiatives: Top ten energy saving initiatives.
- Simple on-line calculator to help end users understand pay back economics.
- Best in class equipment (30% saving) versus least cost.
- Higher thermal rating (range of opportunities and paybacks).
- Cost impact of poor operation (leaving doors open).
- Educate the trade on how to successfully install, commission and maintain equipment.
- Operational manual for contractors to give end users.
- Consider co-benefits - look at the problem in terms of energy savings as well as improved shelf life of produce.
- Specialised technical education can be used to form what is classified as a "Master Tradesperson" qualification and/or licensing system.[11]

[11] *A Master Tradesperson framework is used in some European countries including Germany and Denmark.*

9 Industry feedback

Common themes from this research included:

Theme	Issue
Behavioural	Equipment beyond life expectancy is not being replaced. Clients continually patching up with repairs, in some circumstances on equipment nearing 40 years old.
	Leaving doors open to provide cooling in hot kitchens.
	Sometimes the doors can remain open as much as 8 hours per day (i.e. logged at independent supermarket).
	Removal of plastic curtains by staff to improve convenience when accessing the WICF.
	The contractor behaviour (i.e. poor communication, minimal training, declining skills and SME business culture) is considered a significant barrier. They are also driven by least cost behaviour and the contractor undertaking the installation is not necessarily the contractor undertaken the service and repairs.
Design	There is scope for a voluntary quality assurance scheme for Heat load software calculations based on standardised components, where the software limits the user to remain within certain temperature differences across heat exchangers, certain compression ratios, certain fin spacings, certain pipe sizes, certain refrigerant GWP's and certain pressure drops.[12]
	Businesses often buy the minimum sized WICF to meet their requirements for cost reasons then tend to overload the room resulting in poor air flows (i.e. stacking produce in front of evaporator air flow).
	SMEs do not have engineers to guide end users on good practice.
	There is opportunity to reduce the size of the equipment as Heat loads are typically undertaken by wholesalers and include significant safety factors.
Design (cont'd)	Person undertaking the design is often not considering the surroundings to optimise the design.
	Smaller WICFs are more subject to design to the lowest dollar which leads to system inefficiencies.
	No floor insulation, then use of perimeter heating to avoid condensation.
	Not well thought out design in regard to evaporator selections and capacity.

[12] *KKO (Kølebranchens Kvalitetsordning), Denmark provides Heat load software (incl. English version) subject to a license agreement, annual licensing fee and annual license renewal subject to training in software updates and the use of these updates. Only systems that have passed the stringent design requirements prescribed within the framework of the software are entitled to carry the quality label.*

Theme	Issue
	Strip curtains to all external doors, and fan cut-off switches.
	Avoid heat rejection into the kitchen.
	Often no thought from architect where the refrigeration plant is located. In high density mixed dwelling (i.e. residential and commercial) it is common to place plant in poor locations in the carpark with limited capacity to reject heat.
	Refrigerants with GWP values >150 are unlikely to have a long term future. For example, the EU F-Gas Regulations impose a range of GWP based restrictions on commercial refrigeration equipment due to come into force from 2022.
Regulation	There was a view regulation is required to drive change, however regulation is not possible without a framework, code of practice or technical standard.
Education	The majority of contractors working on this equipment are smaller businesses. These are the ones that need to be reached for education. This needs to be tackled at the end of the industry that deals with small business.
	End-user education regarding the cost benefits of correctly selected equipment. The training of staff using the WICFs is important as most waste is in the incorrect application, loading, leaving doors open, ignoring poor performance and lack of visibility of power consumption.
Equipment	When components are replaced sometimes they are replaced with the lowest cost fan rather than the same or right fan. Common to see different or incorrect fans on existing condensing units and evaporators.
Installation	Poor pipe insulation. The NCC specifies insulation requirements for pipe diameters >5/8" that says it should be 19 mm thick insulation. Wholesalers sell a lot of 13 mm.
	Pipework and electrical entry points not sealed.
	Poor commissioning, particularly not setting up superheats correctly lead to poor performance, this seems to be an area of the trade that is being lost due to a lot of refrigeration mechanics doing an entire apprenticeship servicing air conditioning and installing split AC units.
	Not sealing joins and repairing seals (silicon and door seals are cheap).
	Incorrectly matched and uncommissioned equipment are some of the key issues. For example, TX out of the box (i.e. superheat not set up) is very common practice.
Operational	Often a disconnect between installation and service. Contractors that install the WICFs are not the same people that service.
	Correct refrigerant charge and cleaning coils are the obvious maintenance items.

Theme	Issue
Structure	Poor design of door frames (i.e. aluminium) and heaters (i.e. w/m too high) resulting in them being too hot.
Technology	HFC-404a (GWP of 3922) is still the most common refrigerant in commercial refrigeration although there are plenty of low GWP alternatives available including HFO blends HFC-448A (GWP of 1387[AR4]) or HFC-449A (GWP of 1397[AR4]).
	Energy efficient solution for medium temperature applications can be achieved with HFC-134a (GWP of 1430). This also has the benefit of HFC-513A, also referred to as XP10, (GWP of 573) as being a retrofit at a future date.
	Best practice: package trans critical CO_2 equipment. Electronic expansion valves, variable speed compressor, EC fans with pressure control and leak detection installed inside condensing units over a certain size. Minimum standard for refrigerant GWP ≤ 1430.
	There is a lack of cost competitive natural refrigerant options for WICFs.
	Mechanical expansion valves are selected instead of electronic expansion valves.
	Variable frequency drives are rarely installed.

10 AIRAH position on low-emission walk-in cool rooms and freezers in a net-zero future

For net-zero to become a reality in the refrigeration and air conditioning sectors, AIRAH advocates for low-emission WICF systems, which means:

- The thermal performance and the air ingress characteristics must all be optimised to ensure that the minimum amount of energy is required.
- The thermal performance of structure (i.e. walls, ceiling, doors, floors and glazing) of WICFs are to have an R-values consistent with worlds best practice to suit local ambient conditions.
- Minimise the use and size of transparent windows and doors. Glazing on cool rooms to be double glazed and triple glazing on freezers with all glazing to have heat reflective treatment and inert gas fill.
- The design, construction and operation of the WICF must minimise air infiltration as it is the major and most variable Heat load.
- Methods to achieve minimise air infiltration include:
    - Structure that achieves a full vapour seal with all penetrations correctly sealed.
    - Doors strips, spring hinged doors, automatic door closers on doors for WICFs with fork truck access, evaporator fan cut-off switches and alarms to minimise air infiltration when doors are opened for operational purposes.
- Systems are accurately sized to reduce system load and meet documented realistic operating and product load requirements.
- Systems are installed, controlled, commissioned, monitored, operated and fine-tuned to ensure optimised energy consumption.
- Low-GWP working fluids and tight system construction standards, minimising leaks and maintaining an optimum refrigerant charge.
- Dedicated WICF controllers that adopt an integrated approach that connects the key components to achieve flat line temperature control (as close as practically possible) and include other features such as demand defrost, data logging, system self-diagnostics and alarms, and maintenance reminders and logs.

Low-emission WICF systems cost more to procure than the industry standard but costs less to operate and generates better long-term outcomes for businesses, owners, and the environment.

11 Findings from the research

The existing WICF supply chain is almost completely unregulated with very minimal to no guidance for contractors and end users regarding what constitutes minimum or good practice regarding design, installation commissioning or maintenance.

Supplying, installing and maintaining WICFs is complicated and the industry participants are very disconnected, with issues on multiple levels and significant opportunities for improvement.

There is:

- No good practice guideline or technical standard for WICFs that covers design, installation, commissioning and maintenance;
- No requirement to undertake a Heat load calculation for a WICF (i.e. required for air conditioning);
- No documentation provided to the contractor or end user (i.e. installation, commissioning, operation, maintenance);
- No requirement for specific skills except a refrigerant handling licence (RHL) when installing equipment that requires charging with refrigerant;
- No certificate of compliance required except when electrical works is involved;
- Drop-in/slide-in units are self-contained (or packaged equipment) and therefore do not require a licenced refrigeration technician to install them;
- Insulated Panel Council of Australia (IPCA) Code of Practice that covers structures built using Insulated Sandwich Panels (ISPs) and Expanded Polystyrene Fire Resistant (EPS-FR) insulated panels. The IPCA Code of Practice provides no guidance on energy efficiency and is mostly about construction and fire risk mitigation. The code is adopted by around 40% of the industry;
- Unlike the large majority of all other building structures in the economy, the National Construction Code (NCC) has no energy efficiency requirements;
- NCC has some requirements for new WICFs such as emergency exit, bell on door, etc.;
- No efficiency measure or label for end user to understand what the WICF may cost to operate or what constitutes poor or good efficiency (i.e. no star rating); and,
- Information failure, split incentive and least cost purchasing are the primary reasons for energy waste in the WICFs sector.

12 Recommendations:

The key recommendations following the industry consultation and research are:

- A Code of Practice that encompasses design, installation, commissioning and maintenance is strongly recommended;
- Industry training based on the Code of Practice is strongly recommended;
- A deemed to comply star rating system and label should be considered:
  - Communicates to key stakeholders (i.e. contractors and end users) what constitutes poor and high efficiency WICF;
  - Provides framework for incentives via deeming method in the Victorian Energy Upgrades program; and,
  - Both information and incentives will assist with key barriers to energy efficiency in this sector (i.e. no guidance or information and least cost purchasing by SMEs).
- The documentation, operation and maintenance requirements due to come into force via AS/NZS 5149 part 4:2016 can be reinforced in the Code of Practice (refer section 7.3 for overview of requirements);
- The maintenance requirements in the Code of Practice should be encompassed in AIRAH DA 19 HVAC&R maintenance;
- A star rating label and rating plate for WICFs under the GEMS Regulations should be considered as a mandatory or voluntary measure to assist with barriers to energy efficiency;
- Sustainability Victoria to consider communication for end users such as operator guide and maintenance guide reminding end users of their obligations under AS/NZS 5149 part 4:2016 and how to operate and maintain WICFs efficiently;
- Undertake behavioural insights research / ethnographic study to better understand installers and users behaviours and what drives them;
- Other tools that should be considered are:
  - Payback calculator and industry agreed assumptions for communicating energy savings; Or industry agreed assumptions in the Code of Practice and provide scope for supplier calculators;
  - Once a Code of Practice is established this provides scope for inclusion in other standards and regulations (i.e. National Construction Code, The Ozone Protection and Synthetic Greenhouse Gas Management Act 1989, related Acts and requirements of the Refrigerant Handling Licence); and,
  - Industry standard Heat load calculator (this carries risks).
- Minimum energy performance benchmarking in larger cold storage facilities beyond the scope of WICF in the form of prescribed maximum specific energy consumption values (SEC) in kWh/m^3 per annum that vary greatly throughout industry.

End of Report

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